# SNOWPACK STABILITY TESTS

—Mark Moore, NWAC (© 2004)

Because each different layer of snow can respond to applied stress in a variety of ways, and because the mechanical properties of snow layers often change very dramatically over space and time, it is very difficult if not impossible for one simple mechanical test to determine whether or not a slope can avalanche. Often this can only be definitively answered by actually skiing, riding, hiking, climbing or boarding the slope in question–which is <u>not</u> recommended as a mechanical test except in the context of slope cuts or ski testing, preferably on small safe(r) slopes. However, there are a variety of simple field tests available that can safely aid in the stability analysis process, and these include the Rutshcblock, Stuffblock, Compression (or tap) Test, and Shovel Shear. When these tests are used in combination with all the other snowpack, weather and terrain factors out there–and when they are repeated often enough to appropriately sample the spatial and temporal variability of snow–then they can help to determine avalanche potential. One of the most important results hoped for with any of the following mechanical stability tests is repeatability. That is, redundant results help reinforce the validity and trustworthiness of any of the tests, especially if the redundancy extends from pit to pit and slope to slope. Remember… <u>Useful Snow Stability information is hardly ever derived from just one test or one snowpit. It involves a process—an evolution of stability assessment…with snow profiles and tests being just one part</u>.

For practical purposes in many applications, most of the snowpack stability tests discussed here can be categorized into the three basic awareness of stability levels of red, yellow and green (introduced and popularized by Doug Fesler and Jill Fredston in their avalanche safety guide *Snow Sense*[1]) —

- Red light (No Go)
- Yellow Light (Caution) — be conservative, more tests recommended
- Green Light (Go)

In addition to the internationally accepted test descriptors and classifications, wherever possible test results can also be approximated in the Red-Yellow-Green or GO / NO GO rating system (see Table 1 below) that gives ***<u>rough</u>*** correlations between various tests and the estimated stability level. Be aware that these are ROUGH correlations, and proper application involves practice and consideration of all factors in the data triangle (snowpack, weather, terrain and the human factor). Also note that accident research has shown that human triggered avalanches still can and occasionally do occur with Rutschblock scores of 6 and 7 and a Green/Go rating level.

[1] Fesler, Doug and J.A. Fredston, *Snow Sense*, Alaska Mountain Safety Center, Anchorage, AK, 1994.

**Table 1. Rough Comparison of Common Snowpack Tests**

Compiled and prepared by Mark Moore, NWAC (© 2004)

| Meaning/ Stability | Numeric rating | Common rating | Type of Test ---------------- Stability -------------- | | | \|---Shear--- |
|---|---|---|---|---|---|---|
| | | (Abbreviation) | Rutschblock RB | Compression CT | Stuff block SB | Shovel shear ST |
| **Unstable** (similar slopes may fail when skied) | **1 Red** | Collapse (C) | Fails when isolating block | Fails when isolating column or laying shovel on column | Clean shear while isolating column or with weight of sack | Block settles when cut |
| | | | **RB1** | **CTC** | **SBC** | **STC** |
| **Unstable** | **2 Red** | Very Easy (V) | Fails while approaching or stepping on block | 1-7 taps (articulate from wrist) | Fails cleanly with weight dropped from 10 cm (4 in.) | Fails cleanly during cutting or insertion |
| | | | **RB2** | **CTV** | **SBV** | **STV** |
| **Unstable** | **3 Red** | Easy (E) | Fails with sharp knee bend / unweight | 8-12 (wrist + elbow) | Fails with weight dropped from 20 cm (8 in.) | Fails with minimum pressure |
| | | | **RB3** | **CTE** | **SBE** | **STE** |
| **Marginal** (marginally stable) | **4 Yellow** | Moderate (M) | One jump (large) | 13-17 (elbow) | Fails with weight dropped from 30 cm (12 in.) | Fails with moderate pressure |
| | | | **RB4** | **CTM** | **SBM** | **STM** |
| **Marginal** | **5 Yellow** | Moderate to Hard (MH) | A second jump (large) | 18-22 (elbow + arm) | Fails with weight dropped from 40 or 50 cm (16 or 20 in.) | Fails irregularly with moderate pressure |
| | | | **RB5** | **CTMH** | **SBMH** | **STMH** |
| **More stable** (lower potential for triggering) | **6 Green** | Hard (H) | Jump ½ way down or multiple large jumps | 23-30 (arm) | Fails with weight dropped >50 cm (>20 in.) | Fails after firm, sustained pressure |
| | | | **RB6** | **CTH** | **SBH** | **STH** |
| **More stable** | **7 Green** | No failure (N) | No failure | No failure | No failure | No failure |
| | | | **RB7** | **CTN** | **SBN** | **STN** |

In the **rough** guideline meanings above:
**Unstable** indicates that avalanche slopes with similar conditions (including aspect and slope angle) are likely to be triggered by a skier,
**Marginal** indicates marginally stable conditions (skier triggered slab releases are possible and more tests are indicated to assess stability; conservative route selection is recommended),
**More Stable** indicates a low (but not negligible) potential of a skier-triggered avalanche on a similar slope

**Table 2. Comments on Tests**

| Test | *Comments* |
|---|---|
| **General** | • All tests need repeatability to increase confidence in results;<br>• Note slope angle and aspect;<br>• Most tests decrease/increase 1 level for each 10 degree increase / decrease in slope angle;<br>• Quality of shear [1-clean and fast (paper), 2-normal (scissors), 3-uneven & irregular (rock)] is important to note and apply to test interpretation—see below<br>• Need to identify weak layers and try to correlate with past weather to estimate aerial distribution (local vs widespread) |
| **Rutschblock (RB)** | • Limited to upper 1 m of snowpack;<br>• Not for deeply buried weak layers;<br>• Normal size 1.5m upslope x 2 m across slope, slightly angled in at top;<br>• Must cut back wall to be meaningful as Rutschblock or else notate;<br>• Size and orientation may be modified for boarders, snowshoers and snowmobiles—note this change in shape under comments;<br>• Roughly related to red light (RB1-3), yellow light (RB4-5) and green light (RB6-7) conditions<br>• May not be representative or meaningful for hard near surface crusts, hard slabs or more deeply buried persistent weak layers (e.g., surface hoar, faceted grains) |
| **Compression (CT)** | • Limited to upper 1.2 m (120cm) of snowpack;<br>• Good correlation with Rutschblock;<br>• Decrease 1.1 taps for each 10 deg increase in slope angle;<br>• Good for new snow instability;<br>• Quantifiable—normally more consistently repeatable results than shovel shear<br>• Rough correlation with red light (1-10), yellow light (11-20) and green light (>21 taps) conditions<br>• Results may vary between testers and force applied |
| **Shovel Shear (ST)** | • Small sample size—need repeatable results<br>• Size normally ~30x30 cm—25x25 cm okay and little effect;<br>• Shape and size of shovel has limited effect;<br>• Location and strength of layers only—not a stability test;<br>• Use care not to lever column;<br>• Better than compression for old snow and buried weak layers > 100-120 cm deep |
| **Stuff block (SB)** | • Small sample size—need repeatable results;<br>• Size 30 x 30 cm; weight of 4.5kg (10 lbs);<br>• Quantifiable results like compression test;<br>• Results approximate Rutschblock scores<br>• Works best with near surface / new snow instability |
| **Loaded column (LC)** | • Small sample size—need repeatable results;<br>• Quantifiable results like compression test, but difficult to gage quantity (snow density) of loading applied |

# Shear Quality (Q)—
# the "*nature*" of the fracture

As mentioned in the general comments section of the above table, the **quality of the shear** tells a great deal about the bonding at the shear plane. An irregular shear surface indicates some bonding and strengthening has begun between layers, while a clean shear surface normally indicates a weaker attachment between snow layers. In either instance, it is common practice to examine and try to identify snow grains scraped from either the bottom of the block that failed or from the top of the bed surface or weak layer remnants left behind. Noting the Shear Quality (Q1, Q2 or Q3) when recording stability test results can give important information about the presence and persistence of suspected weak layers, as smooth fast shears often indicate surface hoar or very weak bonding to a smooth bed surface (like a rain crust or ice lens)—weakness that may last awhile. [Note that a more stable stability test number (higher Rutshcblock, harder shear) combined with a Quality 1 shear may often be more important than a less stable test number (lower Rutschblock, easier shear) with a low Quality 3 shear, since the weak layer or bonding of the potential slab is really what is most important.] The following list gives a brief description of shear quality and its field interpretation. See the paper by *Johnson and Birkeland, 2002*[2] for a more complete analysis of shear quality.

- **Q1— Unusually clean, planar, smooth and fast shear surface;** weak layer may collapse during fracture and slab may slide into pit on slopes angles > 35°
- **Q2—Average" shear, mostly smooth** but slab does not slide as readily as Q1; fracture occurs throughout most of slab but some small irregularities possible—not as many as Q3
- **Q3— non-planar shear surface, uneven, irregular and rough**; shear fracture typically not through the whole slab/weak layer interface. Slab may experience only slight movement

[2] Johnson, R.F. and K.W. Birkeland. 2002. Integrating shear quality into stability test results. *Proceedings of the 2002 International Snow Science Workshop*, Penticton, BC, Canada 508-513.